System Representation

A dynamic system can be represented in two different ways: in **state-space representation** or in **transfer function / frequency representation**.

State Representation Types

State representation itself splits into two different types:

- **LTI** — Linear Time-Invariant
- **LTV** — Linear Time-Varying

LTI System

$$\dot{x} = Ax(t) + Bu(t) \tag{1}$$

$$y = Cx \tag{2}$$

LTV System

$$\dot{x} = A(t)x(t) + B(t)u(t) \tag{3}$$

$$y = C(t)x(t) \tag{4}$$

LTI systems do not have their system matrices varying with time. That is, A, B, C, D do not vary with time.

System Matrices A, B, C, D

A: Explains how the state vector $x(t)$ and its changes actually affect the system's future behavior. Systems builds on itself and evolves based on its past values over time. The A matrix defines how the past/current state vector influences the future system state and behavior. This matrix is crucial for modeling and predicting the system. For simple systems without a control input component, matrix A is the model and prediction mechanism.

$$A \in \mathbb{R}^{n \times n}$$